

**DESERTS OF THE SOUTHWEST**  
**Lecture Notes**  
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*There is no shortage of water in the desert, but exactly the right amount, a perfect ratio of water to rock ... there is no lack of water here, unless out try to establish a city where no city should be.*

Edward Abbey, *Desert Solitaire*

**DESERTS**

1. What is a desert?

- (1) An arid place, created by draughts – long and unpredictable periods of little or no rain.
- (2) Places where water is severely limiting to life most of the time.
- (3) Places that receive an average of less than 10"(250mm) of rainfall annually. Or, that receive less than 10"of rain AND have an annual evaporation of 10" or more.
- (4) A place where aridity, as measured by the PET/*p* ratio\*, is 3.0 or higher.

\*Potential Evapo-Transpiration/Precipitation

- Potential evapo-transpiration (PET) = the water that would be lost from evaporation + transpiration if water were present to evaporate. Estimated to be 60% of pan evaporation.
- Tucson receives about 12" (305mm) of rain/year: pan evaporation is about 100" (254cm). Tucson's PET/ *p* ratio  $60/12 = 5$  (using the 60% estimate).

PET/*p* ratio 3-30 = arid desert

PET/*p* ratio 30 or higher = hyperarid desert

2. Amount of rainfall is correlated with predictability of rainfall -- less annual precipitation = less predictability.

3. Why is the American southwest is a desert?

(1) A double rain-shadow effect. Coast Range on the W (Cascades & Sierra Nevada) blocking most of the Pacific storms, and Rockies on the E.

(2) The horse latitudes, 30° N and S: cool dry air descends back to earth from the upper atmosphere.

## ORIGINS OF AMERICA'S SOUTHWESTERN DESERTS

1. The origins of America's deserts were 30MYA -- uplift of the Coastal Ranges created western rain-shadow barrier.
2. Modern landscapes in the SW developed 8-15MYA, when basin & range topography developed. All of N. America's deserts lie within the Basin & Range Province.
3. Over past 2 MY, southwest climate has experienced 15-20 glacial episodes, each lasting 10,000-20,000 years.
4. Last extensive glaciation began drawing to a close 10,000 years ago. At its glacial peak, sea level was 450 ft (130m) lower than today. The Bering Strait was narrow and iced-over, allowing for the migration of humans into the New World.
5. Today's desert communities had their origins less than 10,000 years ago, as the last glacial ended and climates warmed (i.e. the Holocene).
6. Records from pack rat middens tell us that during cooler periods juniper & pine dominated S Arizona. During warmer times, the woodlands migrated up the mountains – hence Arizona's "sky islands."

## SW DESERT SOILS

1. *Bajadas*: alluvial deposits that flank desert mountains; coarser soils at top, finer soils at base. Sonoran Desert bajadas & alluvial deposits harbor the most diverse plant assemblages in North America.
  - Bajada alluvials accumulate at a rate of around 2 cm/year. River bottom alluvials accumulate at a rate of foot or more/year.
2. SW desert soils accumulate 2 distinct layers: a clay layer (the argillic horizon), and a calcite layer (the calcic layer).
  - Both are derived from weathering of parent rocks and by wind-transported dust.
3. Argillic layers store water by preventing it from passing into deeper soil layers. Plants with shallow roots take advantage of this temporary "perched" water table (*e.g.* most cacti, bursage).
  - Thick calcic layers (caliche) are almost like concrete, and limit the depth of root penetration by plants.
  - On the B2C campus, Pleistocene-age clay and caliche layers have been exposed by weathering. Red-brown soils are weathered clays; white-gray soils are weathered caliches. The plant communities inhabiting these 2 soil types, and alluvial soils, differ.

## **THE HOLOCENE MEGAFUNAL EXTINCTION EVENT**

1. In the late Pleistocene/early Holocene, a rich community of large mammals (megafauna) occupied the SW. This assemblage included 34 species of large (>40kg) mammals -- 23 of these went extinct over the first 2,000 years of the Holocene, 19-11,000 years ago.

- This Holocene extinction coincided with the appearance of the first hunter-gatherers in the New World (Clovis people).
- No extinct Holocene mammal remains have been found in archaeological sites postdating Clovis.
- And there are many records of Clovis points associated with the large mammal kills.
- For these reasons, Paul Martin hypothesized that Clovis people drove the Pleistocene megafauna to extinction by over-hunting during the early Holocene Period.

2. Recent claims for human occupation predating Clovis:

- Julian Hayden's work in The Pinacate places the first human appearance in the SW at 40,000 years BP. (based on a single C-14 date from a midden shell, and a controversial desert varnish date).
- Monte Verde site in S. Chile is reliably dated at 20,000 years BP.
- Recently discovered site in Virginia is reliably dated at 18,000 years BP.

## **NORTH AMERICA'S FOUR GREAT DESERTS**

Great Basin, Mojave, Chihuahuan, Sonoran

See accompanying summary table.

## **THE SONORAN DESERT**

1. Extends over 12 degrees latitude: 23°N to 35°N. More than 2/3 of it lies in Mexico (Sonora and Baja).

- S limit (on mainland) is at Guaymas, where the Sonoran Desert grades into the tropical Sinaloan Thornscrub Province.

2. A sub-tropical desert (= Kalahari, Namib, Patagonian Deserts)

- All lie on or near the Tropics of Cancer or Capricorn and are either horse-latitude or rain-shadow deserts.

3. Most striking feature of the Sonoran Desert is biseasonal rainfall pattern.

- Summer tropical convection storms bring "monsoons."
- Winter cold storm fronts from the NW Pacific bringing light rains.
- Fall and Spring are draught periods.

4. The biseasonal rainfall pattern and the rarity of hard freezes gives the Sonoran Desert a very high biodiversity. Plants & animals can specialize for two wet periods each year -- temporal partitioning of resources by plant & animal communities.

- Freezing temperatures occur only a few nights out the year.
- Measured by unit area, the Sonoran Desert is the most diverse of the American deserts.

5. Vegetation of the Sonoran Desert is derived from the humid tropics – to the south. Whereas the other 3 North American deserts are dominated by low shrubs, the Sonoran Desert is characterized by large trees and columnar cacti, with only the dry lowlands being dominated by creosote-brittlebush-bursage communities.

- Large legume trees: e.g. paloverde, mesquite, ironwood.

- Columnar cactuses: e.g. saguaro, cardon, organ pipe, senita.

- In some areas, creosote and bursage account for up to 90% of the plant cover.

- Riparian zones along rivers are home to the Sonoran Desert's only deciduous trees: cottonwoods, ash, and sycamore. However, most of these rivers have become dry in historic times, due to human exploitation of water.

6. Facts about the Sonoran Desert:

- Covers 100,000 mi<sup>2</sup> (320,000 km<sup>2</sup>), in 2 countries and 5 states.

- 130 species of mammals,

- 20 amphibians,

- 100 or so reptiles,

- 30 native freshwater fishes, &

- more than 500 birds,

- 3500 native species of plants (more than 5000 species of plants occur in the states of Sonora, Arizona, Baja Norte and Baja Sur)

- All the world's great biomes occur within the boundaries of the Sonoran Desert: Tundra, Coniferous Forest, Temperate Deciduous Forest, Grassland, Chaparral, Desert, Tropical Forest.

## **BIOTIC REGIONS OF THE SONORAN DESERT**

- Forrest Shreve described the unifying features of the Sonoran Desert (1950s), on the basis of plant communities. He designated 7 regions. Turner & Brown (1982) enlarged Shreve's work using temperature and rainfall data, producing the classification system used by most people today. The Turner and Brown system recognizes 6 regions (see handout).

Principal Regions (= Subdivisions) of the Sonoran Desert

- (1) Arizona Upland – wettest Region of Sonoran Desert
- (2) Lower Colorado River Valley – driest Region of Sonoran Desert
- (3) Central Gulf Coast
- (4) Plains of Sonora
- (5) Vizcaíno
- (6) Magdalena Plain

2 other "regions" are worth noting:

- (7) Appacherian Scrub Community
- (8) Riparian Communities

## **CONSERVATION STATUS OF THE SONORAN DESERT**

1. 17% of the Sonoran Desert (in the U.S.) is protected in some way.

- The Sonoran Desert has 4 Biosphere Reserves, several federal/state protected regions (e.g. Cabeza Prieta National Wildlife refuge), and federal protection for the islands of the Sea of Cortez.

Biosphere Reserves:

- (1) Upper Gulf of California-Colorado Delta Biosphere Reserve (942,000 ha), est. 1993.
- (2) Pinacate-Gran Desierto Altar Biosphere Reserve (715,000 ha), est. 1993.
- (3) Vizcaíno Desert Biosphere Reserve, Baja California.
- (4) Organ Pipe National Monument.

2. 60% of the Sonoran Desert has been altered by: agriculture, grazing, excessive groundwater pumping, introduction of exotic species, and urbanization.

3. Many animal species are threatened.

- The riverine (riparian) ecosystems of the Sonoran Desert are virtually unprotected. Most of these riverine systems are drying up due to dams and over-pumpage of ground water, and they are also being destroyed by cattle.

- 90% of the riparian areas of the Sonoran Desert have been lost in the past century.

- Many streams that used to be perennial are now washes (*e.g.* Salt, Gila, Santa Cruz & Rillito Rivers).

4. Mountain bajadas and washes are where rain-water soaks into the earth to recharge the water table. These areas are being converted to housing projects and channelized, further reducing ground water/aquifer recharge.

5. Introduced species of high concern include tamarisk, buffelgrass, and several other African grasses, all of which out-compete native species.

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